Hydrogen for Transport; Context setting for Hydrogen Research and Funding Priorities

Robert Evans, CEO, Cenex

Future Hydrogen Production, Supergen DoSH$_2$, Birmingham; 18$^{th}$ October 2011
Hydrogen for Transport is a long term undertaking

...plenty of time for today's R&D to influence the future in ways we can't yet forecast

Large-scale demonstrations projects are underway.

Commerciaiely viable technology is in production.

FCVs are widely available in a selection of vehicles platforms.

Goal: Reduce GHGs by 80% from 1990 levels.

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<tr>
<th>Market introduction</th>
<th>Manufacturing ramp-up</th>
<th>Vehicle population turnover</th>
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| 2010                | 2020                   | 2030                        | 2050

Source: Catherine Dunwoody, California Fuel Cell Partnership, 2009
UKH2Mobility: Roll-Out Scenario Assumptions

**Short-term scenario**
- Centralised hydrogen production
- Brown hydrogen
- National\trans national distribution

**Medium-term scenario**
- Decentralised hydrogen production
- Brown and green hydrogen
- Local distribution
- Long-term storage

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UK R&D Interests
- PEMFC
- Bio-hydrogen production
- Advanced electrolysers
- Advanced hydrogen storage materials
- Coal gasification + CCS
- Light-weighting for H2FCEV

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Inward Investment

Research → R&D → Demonstration 1st Prototypes → Demonstration Small Fleet → Deployment

Innovation Opportunities

Cenex, 2011
Realising a transport-related hydrogen economy requires answers to some interesting questions

- **Production**
  - Where is all the hydrogen we need in the UK going to come from and how will the profile of sources change over time?

- **Distribution**
  - How is the hydrogen going to be distributed to the point of use?

- **Storage**
  - Where are we going to be storing hydrogen and how might the profile of hydrogen storage change over time?
  - What role will new (disruptive) storage technologies play?

- **Use**
  - Who is going to be the hydrogen customer and why?
  - How will they pay for it?
  - What will hydrogen cost and how will it be taxed?

- **Business models**
  - Who is going to invest in establishing what we need to realise a hydrogen economy?
  - What learning can we transfer from the Electrification of Transport sector to aid the transition to a Hydrogen Economy?
Realising a transport-related hydrogen economy requires answers to some interesting questions:

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Activities Route Map

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By Amrit Singh Chandan with special thanks to Gerald Noone, Daniel Symes, Amman Dhir & John Hooper

Source: Birmingham University
Hydrogen Production Options
- Numerous but many are still pre-commercial

- Steam Reforming of methane
- Chloralkali off-gas
- Coal or biomass gasification (with CCS)
- Electrolysis using grid, renewable or nuclear generated electricity
- Photo-electrochemical
- Photo-biological
- Fermentation
- Biomass pyrolysis
- Solar thermochemical

Source: NREL, 2011
The motor industry has its perspective on where Fuel Cell Vehicles fit in the product mix.

Source: General Motors presentation to Hydrogen Technical Advisory Committee
Motor Industry Technology Roadmaps stress the need for breakthroughs in hydrogen storage.

Source: Automotive Council
Onboard Hydrogen Storage is a priority area for R&D

Source: US DOE EERE
But how will hydrogen be stored within the wider distribution system?
– You can’t use Hydrogen without effective storage solutions
Factors will drive the transition to a Hydrogen Economy
....technology innovation influenced by the same factors

- Relative Advantage
- Compatibility
- Complexity or Simplicity
- Trialability
- Observability
‘Hydrogen Communities’ key to Transport Infrastructure Roll-out

High profile locations

Accessible to early adopters

Proximity to high traffic volumes

Long-distance travel capability

Station location set by customer requirements (convenience) and investor requirements (throughput and payback)

Source: Catherine Dunwoody, California Fuel Cell Partnership, 2009
Conclusions

• **Next 25 years will see UK transition to hydrogen economy**
  – Slow diffusion will open up opportunities for today’s R&D to create tomorrow’s disruptive technologies influencing future roll out scenarios for vehicles and infrastructure

• **Hydrogen storage a key priority area**
  – Not just Onboard storage – storage materials R&D will shape the infrastructure deployment for future of production, distribution and use

• **Behavioural Research an important part of the scope of UK R&D**
  – Diffusion of Innovation considerations will drive research questions and set criteria for evaluating the prospects for alternative production and storage technologies
  – Hydrogen communities will be where this transport research is undertaken
  – Relative advantage to be judged against alternative low carbon as well as hydrogen technologies
  – Interest (Cenex and others) to understand the potential role of advanced hydrogen production and storage technologies in the deployment phase of ‘hydrogen community’ research projects